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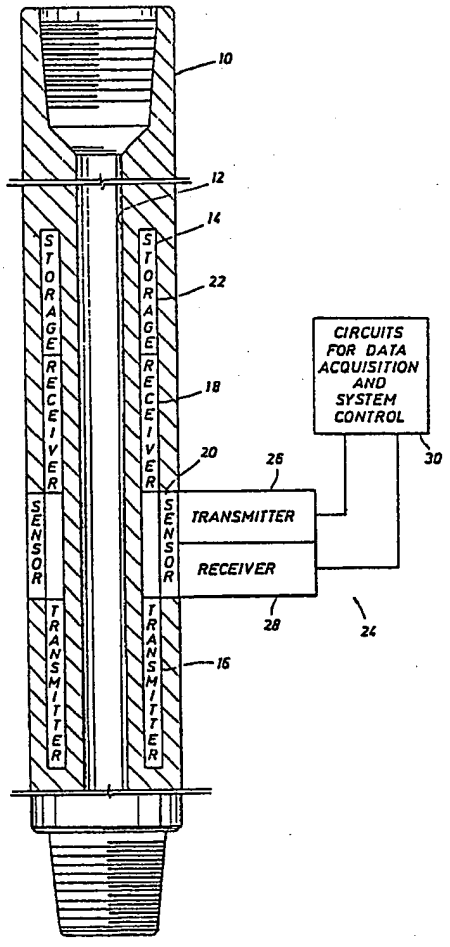
(54) Method and apparatus for communicating with downhole measurement-while-drilling equipment when said equipment is on the surface

(57) In a well drilling/logging system, measured values taken by a down-well measuring unit at a drill bit end are fed to a data storage means in the unit. The measuring unit also includes a transmitter/receiver and is brought to the earth's surface to transmit the stored data conductively or inductively to a surface transmitter/receiver unit for analysis. The surface unit is arranged also to transmit instructions to be read into the measuring unit storage means.



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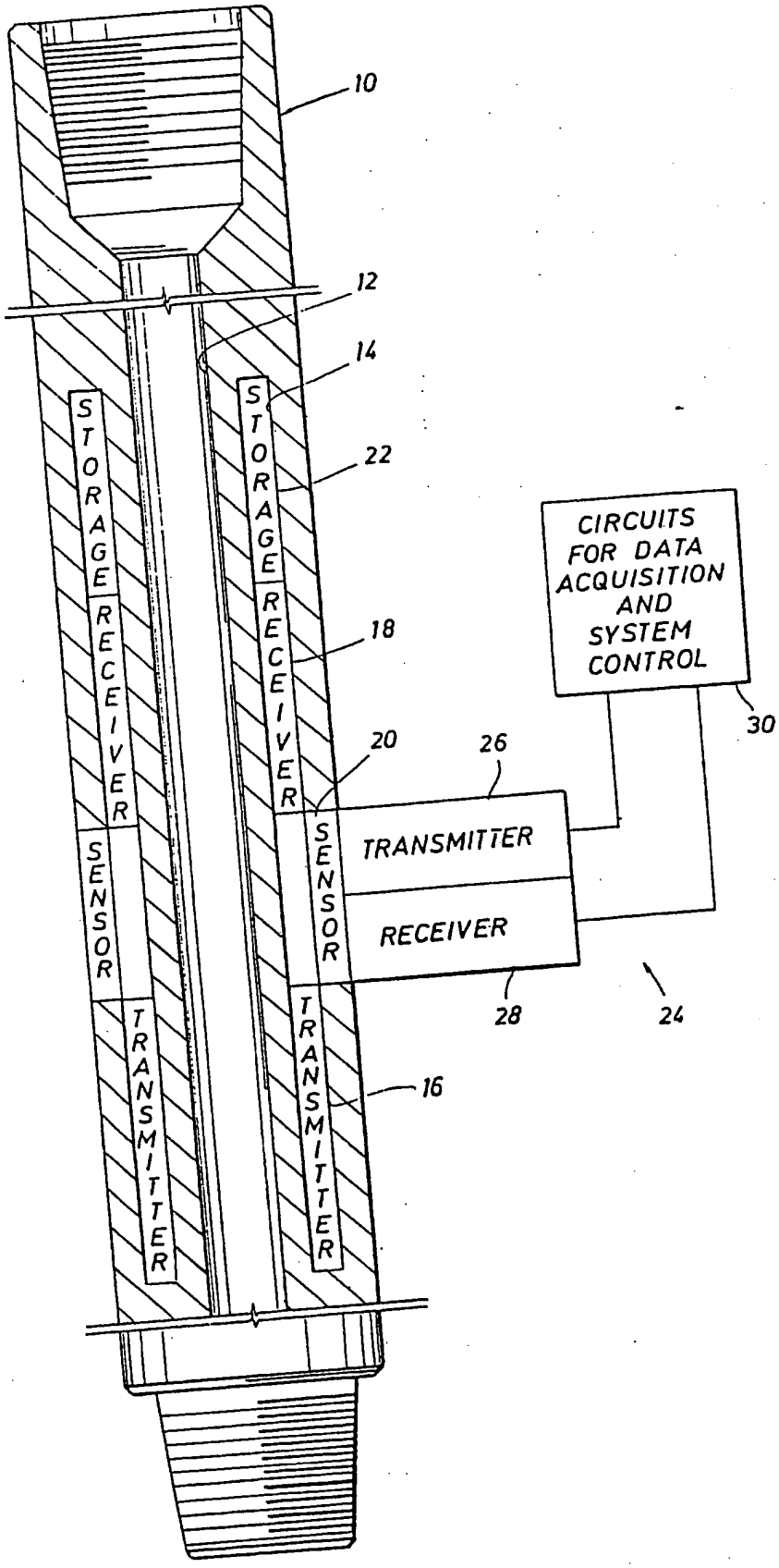
10
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STORAGE RECEIVER
SENSOR
TRANSMITTER
STORAGE RECEIVER
SENSOR
TRANSMITTER
16
CIRCUITS FOR DATA ACQUISITION AND SYSTEM CONTROL
TRANSMITTER
RECEIVER
28
24

SPECIFICATION

Method and apparatus for communicating with downhole measurement-while-drilling equipment when said equipment is on the surface

The present invention is directed to a method and apparatus which is used in conjunction with downhole measurement-while-drilling equipment to establish communication therewith while the equipment-commonly known as a sub - is on the surface.

Recent developments in measurement-while-drilling equipment has produced technological changes in that the downhole equipment is able to accumulate a substantial amount of information, such as detailed descriptions of the various strata through which the drill is passing. Much of this information is extremely important, but not essential to the on-going drilling operation. The drilling operation would require all of the details of the drill bit orientation, so as to correct the advancing boring operation and would be less concerned with the actual strata being penetrated. Thus, the usual telemetry that is provided, either with a mud pulsing system or hard wired system would give priority to the boring information and store the more detailed information concerning the various strata. Other known downhole equipment only records formation data for subsequent recovery and evaluation. It is then possible to recover any stored information when the downhole equipment is periodically returned to the surface for bit replacement.

Prior systems for recovery of the stored data have employed direct electrical connections, which require an aperture to be formed in the wall of the downhole equipment sub. Having an aperture in the wall of the sub creates the problem of weakening the structure creating the possibility of fracturing the sub with the possible resulting loss of the downhole equipment requiring an expensive fishing recovery operation. Other prior art systems have required breaking open of the drill string, at the surface, to either recover recording means itself or gain access to the recording made while downhole.

Measurement-while-drilling resistivity sensors are generally transmitters and receivers of either the current (conduction) type or induction type. Current type sensors include electrodes which are mounted on the surface of the sub for injecting and receiving current directly into and from the drilling mud and formation immediately adjacent to the sub. Induction type sensors include antenna coils on the surface of the sub for inducing and detecting currents into and from the surrounding drilling fluid and formation.

An object of the present invention is to make it possible to provide a method and apparatus for communicating with a measurement-while-drilling sub when the downhole equipment is at the surface and without the need of special connections through a bore or port in the sub. The present invention aims to eliminate this additional port providing a safer, more reliable and easily operated system.

The present invention employs either electrodes or antenna coils to provide an electrical connection between data accumulation and storage circuits within the instrument sub and a data storage and processing device at the surface. The present invention connects or couples a surface deployed transmitter and receiver with the measurement-while-drilling resistivity sensor receiver and transmitter, respectively, preferably while the instrument sub is at the surface, for example during changing of the drilling bit. The surface deployed transmitter and receiver coupled to the sub circuits have the capability of sending operating commands to the measurement-while-drilling sub and receiving from the sub data collected while the sub was downhole. The circuits within the measurement-while-drilling tool must permit data stored within the sub to be transmitted through the electrode/antenna by temporarily disconnecting or blocking the electrode/antenna from its normal operating circuitry (or limiting such operation) to allow transmittal of the stored data. For example, the surface equipment may activate a switching mechanism to temporarily permit the resistivity device to function as a data transmitting system instead of a resistivity measuring (data accumulation) system.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawing in which:

The single Figure shows a schematic section through a typical instrument sub of a downhole assembly at the surface and coupled to communication equipment in accordance with the present invention.

The single Figure schematically illustrates the present invention as it would be used in conjunction with a known downhole measurement-while-drilling instrumentation package. The equipment sub 10 is formed of high strength steel and has an axial bore 12 and an annular cavity 14 in which are placed a transmitter 16, a receiver 18, an electrode/antenna array 20 and a data storage 22. It should be here noted that the present invention will apply to any type of downhole equipment having a transmitter and a receiver operating at any frequency with the primary purpose of gathering borehole information. If the equipment is an electrical sensor, then it can be of a conductive or inductive type, and if it is, then, the conductive type requires electrodes and the inductive type requires antenna. The electrode/antenna array 20 is accordingly mounted at or on the sub's surface with either a single array for transmitting and receiving or with separate sections for transmitting and receiving. It should be noted that the present invention would also apply to acoustical equipment in the sonic range or any other type of measurement equipment operating in any frequency range with appropriate transmitting and receiving means mounted on the sub.

The operation of the measurement-while-drilling equipment is quite conventional with the information being gathered while the equipment is operating downhole and, in appropriate cases, only that data which is necessary to the boring operation being transmitted to the surface. The remaining information, such as strata configurations, would be placed into the storage for readout at a subsequent time. The downhole equipment could also be a system

which would only record while downhole, with all data being recovered when the instrument sub is at the surface.

A surface communicator shown generally at 24 includes a transmitter 26, a receiver 28, and surface circuits 30 for data acquisistion and system control. The surface communicator 24 must be compatible with the downhole equipment so that if the downhole equipment is of the inductive type, the surface equipment would likewise be of the inductive type. The transmitter 26 and receiver 28 of the communicator 24, for the inductive example, would be placed within transmitting range of the equipment sub 10 when the sub is at the surface, for example when the downhole equipment had been returned to the surface for bit replacement. In a conduction or current type system, there would have to be electrical contact between the electrodes as shown in the drawing. While the equipment sub is at the surface, and without being detached from the drill string or without the sub 10 being especially penetrated, the surface communicator 24 is brought to a position where the electrode/antenna of the transmitter 26 and receiver 28 can contact or be coupled to the receiver and transmitter electrode/antenna array 20 of the equipment sub 10. The surface equipment would then instruct the downhole equipment by the transmitter 26 sending instructions through array 20 and the receiver 18 for the data storage 22 to read out and transmit the stored information through the transmitter 16 and the array 20, the information being received by receiver 28 and sent to the circuits 30 where the data will be stored and/or processed accordingly. Once the data transmission has been completed, it is possible to either reprogram or instruct the downhole equipment by transmitting the appropriate information from the surface circuits 30 through the transmitter 26 to the array 20, the receiver 18 and into the data storage 22. The type of information that could be stored would include instructions for the data measuring/acquisition system of the sub 10 regarding anticipated drilling speed and direction or perhaps an expected profile of the geology of the area being bored so as to enable a comparison between the actual and the predicted geology. Also, selections from a menu of measurements that can be made could be loaded into data storage 22.

An alternative embodiment of the present invention would include a sonde mounted within the bore of a sub by appropriate means, such as spider web brackets. The sonde would include data storage and resistivity sensor electronics with the bore mounted sensor electronics connected to sub mounted sensor antenna means. The operation would be the same as described above with compatible surface equipment being coupled to the sensor antenna means to transmit instructions and receive data collected from downhole.

The present invention could also be used in recovering data in any instance where data is collected and stored in a sealed container, and it is desirous to maintain the sealed condition of the container. For example, recovering flow rate data from a pipeline by the present invention would avoid downtime and possible environmentally damaging spills. Other examples would include recovering data concerning activity within a nuclear cell or temperature/pressure conditions within a container housing hazardous materials.

The above-described apparatus normally operate in the radio frequency range. The present invention could also be used with sonic equipment by substitution of appropriate sensors.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the method steps as well as in the details of the illustrated apparatus may be made within the scope of the appended claims.

CLAIMS

1. A method for communicating between surface equipment and a downhole measurement-while-drilling assembly having a transmitter and a receiver, both connected to information storage, and electrode/antenna array means, while said assembly is at the surface, comprising the steps of:

placing within contact/transmitting range of said electrode/antenna array means compatible electrode/antenna array means of said surface equipment; and

communicating directly from data acquisition means of the surface equipment to the downhole equipment to transmit information to and receive data from said information storage.

2. A method according to claim 1 wherein information transmitted from said surface equipment includes instructions for the assembly information storage to transmit data contained in said information storage.

3. A method according to claim 1 or claim 2 wherein information transmitted from said surface equipment includes instructions to be stored in said assembly information storage pertaining to further work of the assembly in a downhole environment.

4. A method according to any one of claims 1 to 3 wherein said electrode/antenna array means are conductive.

5. A method according to any one of claims 1 to 3 wherein said electrode/antenna array means are inductive.

6. An apparatus for communicating with a downhole measurement-while-drilling assembly, while said assembly is located at the surface, said assembly including a transmitter and a receiver both connected to data storage means and to an electrode/antenna array means, said apparatus comprising:

a transmitter and a receiver having a compatible electrode/antenna array positionable within transmitting range of the electrode/sensor array means of said assembly, and

data acquisition and system control means connected to said transmitter and receiver whereby instructions can be sent by said surface transmitter to said assembly receiver instructing transmission of information from said data storage means through said assembly transmitter to the surface receiver for analysis by said data acquisition and system control means and instructions for the downhole equipment

can likewise be transmitted to be stored in said data storage means.

7. Apparatus according to claim 6 wherein said instructions include data regarding downhole operations when said assembly is returned to a downhole environment.

8. Apparatus according to claim 7 wherein said data includes drilling instructions.

9. Apparatus according to claim 7 or claim 8 wherein said data includes expected geological profile information.

10. Apparatus according to any one of claims 6 to 9 wherein said assembly comprises a sonde having a transmitter, a receiver and data storage means contained therein.

11. A method for communicating with measurement equipment forming a portion of a closed assembly without opening said assembly, said equipment including a transmitter, a receiver, information storage and electrode/antenna array means mounted at or on the surface of said assembly comprising the steps of:

placing within transmitting range of said electrode/antenna array means of said equipment compatible readout electrode/antenna array means of data acquisition means; and

communicating directly between said data acquisition means and said equipment to transmit and receive data to and from said information storage.

12. A method according to claim 11 wherein information transmitted from said data acquisition means include instructions for the information storage to transmit data contained in said storage.

13. A method according to claim 11 or claim 12 wherein information transmitted from said data acquisition means includes instructions to be stored in said equipment information storage pertaining to the further data to be gathered.

14. A method according to any one of claims 11 to 13 wherein said electrode/antenna array means are conductive.

15. A method according to any one of claims 11 to 13 wherein said electrode/antenna array means are inductive.

16. An apparatus for communicating with measurement equipment in a closed assembly without opening the assembly, said equipment including a transmitter, a receiver, data storage means, and an antenna/electrode array means, said apparatus comprising:

transmitter means and receiver means positionable to within transmitting range of the antenna/electrode array means of said equipment; and

data acquisition and system control means connected to said transmitter means and said receiver means whereby instructions can be sent by said transmitter means to said equipment receiver instructing transmission of information from said data storage means through said equipment transmitter to the receiver means for analysis by said data acquisition and system control means and instructions for the equipment can likewise be transmitted by said transmitter for storage in said data storage means.

17. An apparatus according to claim 16 wherein said instructions include data regarding future operations.

18. An apparatus according to claim 17 wherein said data includes operating parameters.

19. An apparatus according to any one of claims 16 to 18 wherein said transmitter means and receiver means operate in a sonic frequency range.

20. An apparatus according to any one of claims 16 to 18 wherein said transmitter means and receiver means operate in a radio frequency range.

21. A method for communicating between surface equipment and a measurement-while-drilling assembly, substantially as described herein with reference to the accompanying drawings.

22. Apparatus for communicating between surface equipment and a measurement-while-drilling assembly, substantially as described herein with reference to the accompanying drawings.

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